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Educational Robotics for Physically Active Youth (P.A.Y.)

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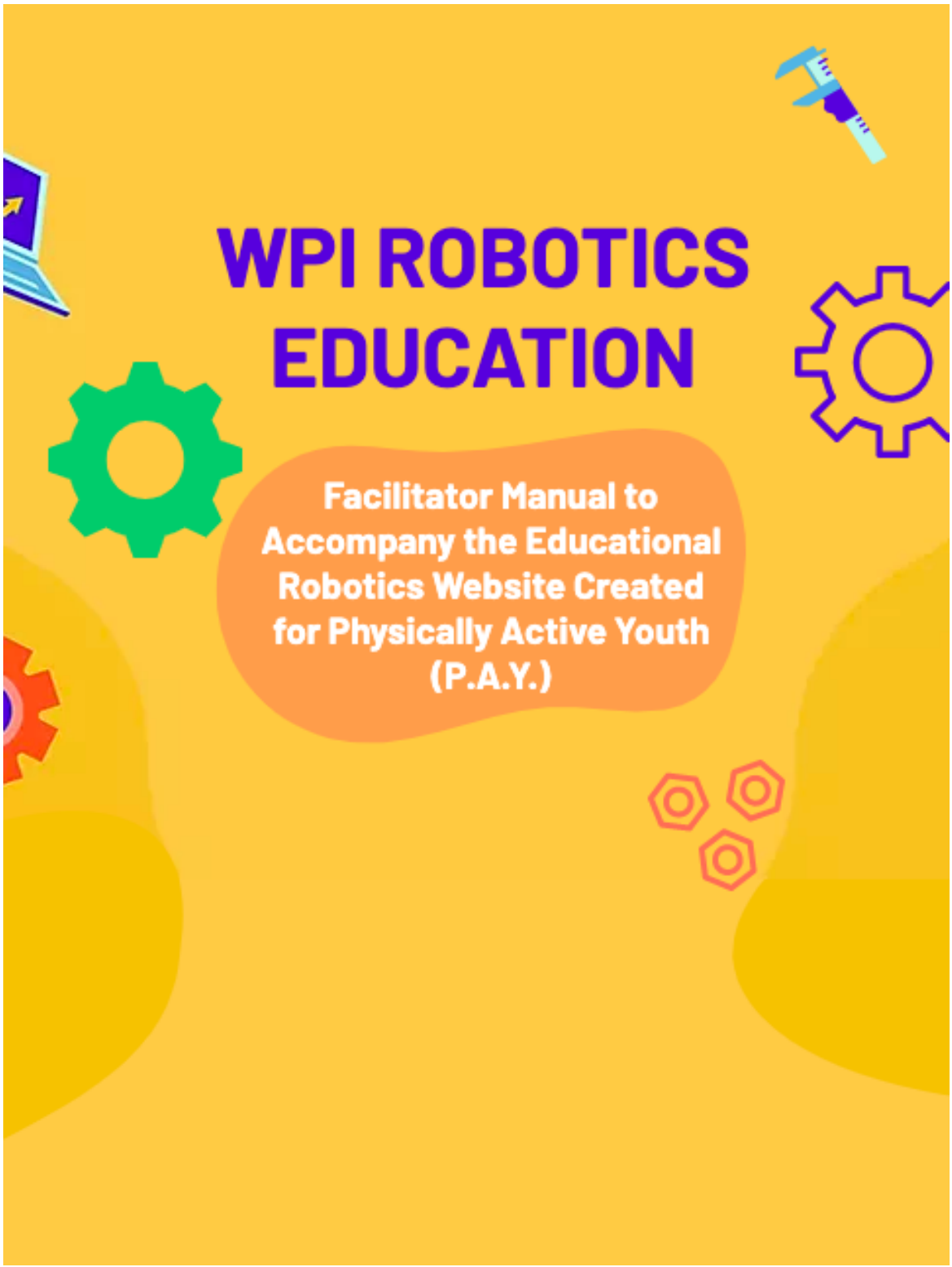
WPI ROBOTICS EDUCATION
Facilitator Manual to Accompany the Educational Robotics Website Created for Physically Active Youth (P.A.Y.)

Table of Contents:

GENERAL RECOMMENDATIONS FOR FACILITATORS OF THESE LESSONS

1. Purpose

a. *Curriculum*

i. This Educational Robotics curriculum was forged by four students as a component of an Interactive Qualifying Project (IQP) for Worcester Polytechnic Institute. The project was initially designed for the delivery of an Educational Robotics Curriculum at Physically Active Youth (P.A.Y.) an after-school program in Katutura, Namibia. Due to extenuating circumstances with the COVID-19 pandemic, the project plan was adapted to involve the remote development of a curriculum enhanced by an online component to be implemented at P.A.Y. at a later date. The lessons presented on the online platform are intended to be supplemented with the use of VEX IQ Robotics Kits, which the WPI students donated to P.A.Y. by the support of a WPI grant and donations from the REC foundation. The aim of this project is to provide an engaging, easy to navigate collection of lessons for the volunteers and educators at P.A.Y. to deliver to students ages 6-18 at a suitable pace. The lessons were built to be used in a classroom/group setting with a facilitator, but are flexible so that they could also be used by students individually.

b. *Facilitator manual*

i. This facilitator manual serves as a guide to provide supplementary and useful information for any/all individuals facilitating students through these lessons. The lessons were designed to provide enough information to standalone on the online platform for completion asynchronously by students. However, in an effort to support educators and volunteers who may or may not have STEM backgrounds and will be facilitating these lessons in a classroom setting, this manual provides lesson details, recommendations, and additional resources for each lesson.

2. Pacing

a. Our hope is that those facilitating the course will deliver the material at a pace that allows adequate time for students to fully understand the concepts, and sufficiently build and test the robots. The lesson specific plans in this guide provide a predicted timeframe that each lesson would take, acting as an estimate based on the volume of content, length of instructional videos, and quantity of activities. Ideally each individual lesson would be completed over the course of 1 or more consecutive days, as the structure of many lessons includes a

presentation of information followed by a challenge or exercise applying the information. This format is most effective when executed over a shorter period of time. In general, we recommend that based on the students' comprehension of the content in the lessons, the facilitator adjusts the pace accordingly.

3. Additional Resources

We used a wide variety of resources to develop the background knowledge necessary to generate all of the lessons in the three age groups. For the purpose of encouraging non-STEM individuals to feel confident preparing for, and delivering the lessons, we have compiled a variety of resources that we used and/or found helpful in understanding this material. We by no means have included all of the resources that exist, but are optimistic that these can provide fundamental concepts and direction for further learning.

a. VEX IQ Robotics Education Guide PDF
    i. This guide has 12 instructional units aimed at elementary and middle school students that provide background, explanations of hardware, build instructions and more. This was an invaluable resource for us as we chose lesson topics, and learned about the VEX IQ kit.

b. VEX IQ Teacher Supplement
    i. This supplemental guide aligns with the 12 units presented in the Robotics Education Guide. This resource includes specific lesson plan information, classroom timing of lessons, and general helpful tips for particularly complex lesson topics.

c. VEX IQ Demos (Youtube)
    i. VEX IQ recorded and published a collection of instructional videos to guide the use of the different components of the robots. These videos can be helpful when applying knowledge-based concepts to the robot. The playlist of videos can be found at the link.

d. VEX IQ Powerpoints
    i. This collection of powerpoints presents a lot of the same information as the VEX IQ Robotics Education Guide PDF, but in a more concise slidedeck that could be used to clarify or go more in depth on a particular concept.

e. VEX Code Program Download
    i. There are detailed instructions on our website regarding the download of the VEX Code software, which allows for the programming of the VEX IQ robot. This site also directly links to the location of the software download.

4. Age Groups

a. The curriculum has been divided into three age groups within the 6-18 year old range, with two levels for each age group (Level 1: no prior robotics/programming experience, Level 2: some prior robotics/programming experience and/or completion of Level 1):

   i. *Beginner (6-10 years old)*
      1. Level 1
      2. Level 2
   ii. *Intermediate (11-14 years old)*
      1. Level 1
      2. Level 2
   iii. *Advanced (15-18 years old)*
      1. Level 1
      2. Level 2

b. The intention for separating the curriculum into separate age groups and levels was to provide a sequential system for students to complete year after year. The material in each age group is aimed at the particular learning level. For example, taking into account the lower reading comprehension in the Beginner age group, there are more instructional videos to promote overall learner understanding. These age groups are only suggestions, and we recommend that students complete the section that most closely aligns with their comprehension level.

5. What Comes Next?

a. If you are looking to expand the robotics program beyond the lessons in this curriculum, you may consider starting a Robotics team. Participation on Robotics teams allows students the opportunity to put the concepts presented in our curriculum into practice, and truly see a design project through from start to finish. More information regarding starting a team and the VEX IQ Challenge program can be found below.
   i. Resources for starting a team
   ii. VEX IQ Challenge Program

BEGINNER			
Level	Intro	**Lesson**	
Topic	Introduction		
Lesson Title	What is STEM?		
Predicted Duration	0-1 hours		
Lesson Objectives			
• Understand what STEM is • Learn what an engineer is • Understand what robots are and what they are used for			
Recommendations			
• If possible, play the videos on the projector so that the group can watch them together • After each video, discuss the main concepts as a group			
Materials/ Equipment			
• Projector			
Vocabulary			
• STEM: stands for Science, Technology, Engineering, and Math • Engineer: someone who wants to know how and why things work. Engineers design and build things • Robot: a machine that is designed by people to do a specific job			
References			
• What is STEM? • What's an Engineer? • Real-Life Robots			

BEGINNER			
Level	1	**Lesson**	1
Topic	Programming		
Lesson Title	What is programming?		
Predicted Duration	1-2 hours		

Lesson Objectives

- Understand what programming is
- Practice the basics of programming through an interactive activity
- Begin using Scratch

Recommendations

- If possible, play the videos on the projector so that the group can watch them together
- After each video, discuss the main concepts as a group
- In step 3: if the students can write, have them write down their instructions for the dance
- If the step 3 activity takes a long time, you may want to begin step 4 on a second day
- If some students complete the activities quicker than others, have them complete the Scratch Challenge Levels

Materials/ Equipment

- Projector
- Paper and pencils (for step 3 activity)
- Computer

Vocabulary

- Programming: giving a series of instructions to a robot or computer

References

- Programming for Kids
- Scratch Programming: Motion Blocks
- Dance Party

BEGINNER			
Level	1	**Lesson**	2
Topic	Mechanical		
Lesson Title	How does a Robot Move?		
Predicted Duration	0-1 hours		

Lesson Objectives

- Learn what simple machines are and build 3

Recommendations

- Have the students build the simple machines in groups of 2-3
- Go over how to read and use the instructions on building simple machines as a group (explain how we show which piece is need and how many by using the “x” symbol)
- If you can, point out simple machines in the classroom
- Create a matching or other vocabulary activity/quiz with the different types of simple machines
- After the students discuss step 4 with a partner, have them share their ideas the the rest of the group

Materials/ Equipment

- VEX IQ kits

Vocabulary

- Wheel and Axle: a wheel and axle work together to help the robot move. When you use them together, the wheel is able to turn and move the robot!
- Inclined Plane: an inclined plane is a surface that is placed at an angle. This angle can help someone get from a low place to a high place easier, like the robot in the picture!
- Wedge: a wedge is similar to an inclined plane, but instead this angled surface is used to push objects, like how the VEX robot is pushing the WPI robot!
- Lever: a lever is an arm that turns at one point and it is used for pulling things apart or lifting things, just like the robot pictured here!
- Pulley: a pulley is a kind of wheel and axle machine that is attached to something like a cord or a rope. When the wheel turns, the rope turns around the wheel, which can be used to make something like a lifting system on a robot
- Screw: a screw is an inclined plane wrapped around a pole. Screws are used to join things together, like pieces on a robot

References

- Simple Machines for Kids

BEGINNER			
Level	1	**Lesson**	3
Topic	Building		
Lesson Title	Building your Robot!		
Predicted Duration	1-2 hours		
Lesson Objectives			
● Build a basic VEX IQ robot			
Recommendations			
● Have students build the robot in groups of 2-3 ● If possible, project the instructions on the projector for the entire class ● Younger students may need additional assistance ● For the brainstorming activity, after students have discussed in small groups have them share their answers with the group ● Talk about the discussion questions as a big group			
Materials/ Equipment			
● VEX IQ kits			
Vocabulary			
None			
References			
None			

BEGINNER			
Level	1	**Lesson**	4
Topic	Testing		
Lesson Title	Testing your Robot!		
Predicted Duration	0-1 hours		

Lesson Objectives

- Test the previously built robots to see if they can lift and hold objects

Recommendations

- Read instructions to the entire group before starting the activity
- If students can write, have them keep track of the different objects they are using for challenges and whether they are able to hold them. At the end of the activity, have students share their successes with the whole group
- Use the projector to display Robbie the Robot's conversation and read it aloud to the group

Materials/ Equipment

- Previously built robots
- Pencils
- Miscellaneous objects
- Projector
- Computer

Vocabulary

- Testing: making sure that your robot can do what you built it to

References

None

BEGINNER			
Level	2	**Lesson**	1
Topic	Programming		
Lesson Title	A Bit of Programming!		
Predicted Duration	0-1 hours		
Lesson Objectives			
• Continue to practice with Scratch • Learn how to use loops in Scratch			
Recommendations			
• Discuss loops as a group and either project the written information on them or write it on the board • Give students extra time to experiment with loops in scratch			
Materials/ Equipment			
• Computer			
Vocabulary			
• none			
References			
• Intro to Programming: Loops			

BEGINNER			
Level	2	**Lesson**	2
Topic	Mechanical		
Lesson Title	All About Gears		
Predicted Duration	0-1 hours		

Lesson Objectives

- Learn the basics of gears and how they work
- Understand how gears are used in everyday life and in robots

Recommendations

- If possible, play the video on the projector for the entire group and discuss gears together
- If possible, show the group an example of gears in real life, potentially using a bicycle as a demonstration tool
    - Note: bikes technically have sprockets, which are slightly different from gears
- Discuss step 2 and step 3 with the entire group, allowing students to give their answers to the questions
- Complete an activity or quiz with the vocabulary
    - Could be a matching game, flash cards, or any other activity

Materials/ Equipment

- Projector
- Anything that can be used to demonstrate gears

Vocabulary

- Gear: a type of simple machine that looks like a wheel with teeth
- Gear train: when gears interlock or connect
- Driver gear: the gear that you turn
- Follower gear: the gear that gets turned
- Gearing up: means you have a large gear turning a smaller gear. When this happens, the small gear moves really fast, but you have less torque, which means the system is not as strong
- Gearing down: means you have a small gear turning a larger gear. The large gear doesn't move very fast, but it has high torque, which means the system is strong

References

- What's a Gear to Do?
- How do Bike Gears Work?

BEGINNER			
Level	2	**Lesson**	3
Topic	Building		
Lesson Title	Let's Build a Robot!		
Predicted Duration	0-1 hours		
Lesson Objectives			
● Build a lift robot			
Recommendations			
● Have students build their robot in groups of 2-3 ● Display instructions on projector for the entire group ● Discuss the 3 options of gear ratios as a class and talk about each group's observations ● If some groups finish quicker than others, allow them to move on to lesson 4 ● Younger students will need additional assistance			
Materials/ Equipment			
● VEX IQ kits ● Projector			
Vocabulary			
● None			
References			
● None			

BEGINNER			
Level	2	**Lesson**	4
Topic	Testing		
Lesson Title	Testing		
Predicted Duration	0-1 hours		
Lesson Objectives			
● Apply programming skills to experiment with the previously built robot			
Recommendations			
● Have students work in groups 2-3 and take turns programming the robot with help from the other groupmates ● Allow groups to try step 1 and step 2 multiple times with different distances and objects ● Discuss step 3 as a class			
Materials/ Equipment			
● VEX IQ kits ● Miscellaneous classroom objects ● Computer			
Vocabulary			
● None			
References			
● None			

INTERMEDIATE			
Level	Intro	**Lesson**	
Topic	Intro		
Lesson Title	What is STEM?		
Predicted Duration	1-2 hours		

Lesson Objectives

- Understand the definition STEM and engineering
- Learn the different types of engineers
- Understand the definition of robotics
- Introduce the engineering design process

Recommendations

- Watch the videos as a class and discuss definitions together
- Check that every student has created an engineering notebook with the right components

Materials/ Equipment

- Notebooks
- If presenting videos as a class, a projector is required

Vocabulary

- STEM: stands for Science, Technology, Engineering, and Mathematics. It combines these disciplines to form an engaging field of study
- Engineering: the use of practical & scientific knowledge to create solutions for identified problems. Engineers use math and science to create most of the products, buildings and structures we see everyday
- Robotics: the specialized type of engineering that deals with the design, construction, operation, and application of robots
- Robot: any man-made machine that can perform work or other actions normally performed by humans. Robots use sensors and processors to perform tasks.

References

- What is Engineering?

INTERMEDIATE			
Level	1	**Lesson**	1
Topic	Programming		
Lesson Title	Programming Palooza		
Predicted Duration	1-3 hours		

Lesson Objectives

- Introduction to programming with loops

Recommendations

- Watch the videos as a class and discuss definitions together
- Give students additional time to experiment in Scratch and encourage them to try different things
- Have the students do an activity or quiz with the programming vocabulary

Materials/ Equipment

- Each student will need a computer with access to Scratch
- If presenting videos as a class, a projector is required

Vocabulary

- Computer Program:a series of steps a computer can follow
- Coding: writing instructions in a programming language
- Code: lines of program instructions
- Algorithm: step by step ordered instructions
- Function: mini program within the code
- Loop: repeat a section of code
- Iterating: testing and fixing the code so it works
- Bug: a problem in the code
- Conditional Statements: when the program looks at an unknown value and does different things depending on what it is

References

- Scratch Website
- Intro to programming video

INTERMEDIATE			
Level	1	**Lesson**	2
Topic	Mechanical - drivetrains		
Lesson Title	All Aboard the Drivetrain		
Predicted Duration	0-1 hours		

Lesson Objectives

- Learn what a drivetrain is and the basic components
- Learn how to minimize your turning scrub

Recommendations

- This lesson might be best received if done as a class with discussions

Materials/ Equipment

- Projector if presenting material as a class

Vocabulary

- Drivetrain - the parts that make up the base of a robot that allows it to be mobile.
- Chassis - the structure of a robot that holds all the pieces together such as motors and wheels.
- Turning Scrub - the friction that resist turning.
- Actuator - parts that control a mechanism. Ex: motor

References

- N/A

INTERMEDIATE			
Level	1	**Lesson**	3
Topic	Building		
Lesson Title	Help Robbie Clear the Way		
Predicted Duration	3-4 hours (2-3 if basebot is pre-built)		
Lesson Objectives			
• Introduction to the engineering design process • Learn how to design a unique solution to a defined problem			
Recommendations			
• Review the challenge and guidelines as a class before students begin designing			
Materials/ Equipment			
• Vex IQ kit • Engineering notebook			
Vocabulary			
• Engineering Design Process - a design process that follows the following steps: Define the problem, plan solutions, make a model, test the model, and reflect and redesign			
References			
• Basebot build instructions			

INTERMEDIATE			
Level	1	**Lesson**	4
Topic	Testing		
Lesson Title	Let's Test with Robbie the Robot		
Predicted Duration	2 -3 hours		
Lesson Objectives			
• Learn how to apply the final steps of the engineering design process. (testing and redesign) • Redesign a robot to complete a challenge using observations from a failed test			
Recommendations			
• Test the robots one team at a time • Debrief as a class the outcomes of this challenge. What went well, what was a challenge, what did they learn from redesigning			
Materials/ Equipment			
• VEX IQ kit • Engineering design notebooks • Block Obstacle - can be build using parts from kit • Computer			
Vocabulary			
• N/A			
References			
• Vex IQ info page			

INTERMEDIATE			
Level	2	**Lesson**	1
Topic	Programming Condition statements		
Lesson Title	Conditional Coding		
Predicted Duration	2-3 hours		
Lesson Objectives			
• Learn how to program using conditional statements			
Recommendations			
• Watch the videos as a class			
Materials/ Equipment			
• Computer with access to Scratch			
Vocabulary			
• Conditional blocks - Programming blocks that follow the if..then format. They allow the code to react to certain events.			
References			
• Conditional Commands Video • Flying butterfly video			

INTERMEDIATE			
Level	2	**Lesson**	2
Topic	Mechanical - Gears		
Lesson Title	Gear Up		
Predicted Duration	3-5 hours		

Lesson Objectives

- Understand gear ratios and how they affect mechanical advantage
- Understand the different types of basic gear ratios and how to build them

Recommendations

- Watch the video and go over the definitions as a class
- Complete the gear ratio activity in groups
- Discuss gear ratio types as a class
- Have students discuss scenarios in partners or small groups and **discuss** as a class

Materials/ Equipment

- VEX IQ kit

Vocabulary

- Speed - Measures how fast an object goes.
- Gear Ratio - The measurement of the arrangement of gears that produce the necessary speed and torque a mechanism requires.
- Torque - Is a force that can produce a rotation.
- Driver Gear - also known as the input, is the gear that will rotate from a power source. Ex: a motor
- Driven Gear - also known as the output, is the gear that rotates from the driver spinning.
- Mechanical Advantage - is the calculation of how much faster and easier a machine makes your work.

References

- Gear Ratio video
- Build instructions for gear ratio mechanism

INTERMEDIATE			
Level	2	**Lesson**	3
Topic	Designing and Building		
Lesson Title	Construction Clean up		
Predicted Duration	2-3 hours - 1-2 if basebot is prebuilt		

Lesson Objectives

- Use the engineering design process to design a unique appendage for completing the challenge

Recommendations

- Before students begin designing, review as a class the challenge and guidelines
- If students are having difficulty with designs, provide examples
  - A plow pushes
  - An excavator scoops
  - A clawbot uses a claw
- Students should record their brainstorms and designs

Materials/ Equipment

- Vex IQ Kit
- Engineering Design notebook

Vocabulary

- N/A

References

- Basebot build instructions

INTERMEDIATE			
Level	2	**Lesson**	4
Topic	Testing		
Lesson Title	Testing with Robbie the Robot		
Predicted Duration	3-4 hours		

Lesson Objectives

- Understand how to build a robot to solve a defined problem
- Understand how to evaluate and redesign

Recommendations

- Review guidelines as a class
- Teams should complete the challenge one at a time
- Complete discussion questions as a class
- Encourage teams to redesign and test again
- Turn this into a fun competition by allowing two teams to complete the challenge at the same time. The team that is able to move more objects to their section wins.

Materials/ Equipment

- Vex IQ Kit
- Miscellaneous objects to represent debris
  - VEX IQ color cubes work best
  - If not available, then any objects small enough to be pushed or carried by the robot
- Engineering Design Notebook

Vocabulary

- N/A

References

- Controller Connection video

ADVANCED			
Level	Intro	**Lesson**	
Topic	Intro		
Lesson Title	Intro		
Predicted Duration	1-2 hours		

Lesson Objectives

- Understand what STEM is and its importance in today's workforce
- Learn the major types of engineers
- Understand the definition of robotics
- Introduce the engineering design process

Recommendations

- Discuss the vocabulary, different types of engineering, and engineering design process as a group
- Discuss the engineering notebook in more detail
    - Provide expectations for how often they should be using it
    - This could be used as a way to assess students' progress

Materials/ Equipment

- Notebooks

Vocabulary

- STEM: stands for Science, Technology, Engineering, and Math, and it is an essential part of education in order to develop valuable skills for the workforce
- Robotics: the specialized type of engineering that deals with the design, construction, operation, and application of robots
- Robot: any man-made machine that can perform work or other actions normally performed by humans

References

- What is STEM?
- Medical Robotics at WPI

ADVANCED			
Level	1	**Lesson**	1
Topic	Sensors		
Lesson Title	Programming!		
Predicted Duration	1-3 hours		

Lesson Objectives

- Understand how robots perceive the world using sensors
- Understand what a bump and ultrasonic sensors are
- Complete the maze programming challenge in VEX VR

Recommendations

- When introducing sensors, associate them with a sense that humans use
  - For example, when discussing the bump sensor, relate it to students using their sense of touch to know when something is nearby
- Before having students use VEX Code VR, try it out to prepare for troubleshooting
  - Demonstrate the different features on VEX Code VR to the students
- To connect this with coding the actual robot, create a simple code using the ultrasonic sensor and show this in VEX Code VR and on an actual robot
- Try having students do other activities on VEX VR that use the ultrasonic sensor
  - Use the “Playground” feature to use different maps and the “Activities” feature to find other challenges
- Give students extra time to experiment in VEX VR and learn the different functions/possibilities
- Make sure that students are writing down something in their engineering notebook for every step (notes, definitions, drawings, brainstorming, etc.)

Materials/ Equipment

- VEX IQ robotics kit
- Projector (recommended)
- Computer

Vocabulary

- Sensors: a device that detects a physical property (input) and responds to it (output)
- Bump Sensor (aka Touch Sensor): senses physical touch to help a robot avoid obstacles
- Ultrasonic Sensor (aka Distance Sensor): measures distance by emitting ultrasonic waves and measuring the time it takes for the waves to be reflected back to the sensor

References

- VEX Code VR Information Page
- VEX Code VR Website

<table>
<tr><th colspan="4">ADVANCED</th></tr>
<tr><td>Level</td><td>1</td><td>Lesson</td><td>2</td></tr>
<tr><td>Topic</td><td colspan="3">Friction and Center of Gravity</td></tr>
<tr><td>Lesson Title</td><td colspan="3">Mechanical Forces</td></tr>
<tr><td>Predicted Duration</td><td colspan="3">1-3 hours</td></tr>
<tr><th colspan="4">Lesson Objectives</th></tr>
<tr><td colspan="4">● Understand what friction is and how it affects robots
● Understand what center of gravity is and how it affects robots</td></tr>
<tr><th colspan="4">Recommendations</th></tr>
<tr><td colspan="4">● Provide a demonstration of both friction and center of gravity in action
○ Friction example: use an object, like a textbook, and find some different surfaces (e.g. grass, carpet, hardwood floor). Pull the object along the different surfaces and demonstrate how it is more challenging on the rougher surfaces and easier on the smoother ones
○ Center of gravity example: use a long object, like a meter stick, and try balancing it at different places to show that it can only be balanced at its center (meter stick is ideal for this because it has an obvious center of gravity)
● Encourage discussion between students when introducing friction and center of gravity
● Possibly do a mini exercise showing a robot that demonstrates friction and center of gravity
○ Students can complete them or it can be a teacher demonstration
○ Examples include building a robot with a long arm and placing objects at the end to shift the center of gravity and having a robot drive over different surfaces to demonstrate the effects of friction</td></tr>
<tr><th colspan="4">Materials/ Equipment</th></tr>
<tr><td colspan="4">● Meter stick (recommended)
● Textbook (or textbook-like object) (recommended)
● VEX IQ Robotics Kit (for creating demonstrations/activities) (recommended)</td></tr>
<tr><th colspan="4">Vocabulary</th></tr>
<tr><td colspan="4">● Friction: a force that resists motion when objects rub against each other
● Center of Gravity: the place on an object where the weight is evenly distributed and everything is balanced</td></tr>
<tr><th colspan="4">References</th></tr>
<tr><td colspan="4">● N/A</td></tr>
</table>

ADVANCED			
Level	1	**Lesson**	3
Topic	Designing and Building a Robot using Sensors		
Lesson Title	Build a Sense-ational Robot		
Predicted Duration	1-4 hours		

Lesson Objectives

- Become comfortable using the bump and ultrasonic sensors on the robot
- Design a robot to solve the problem in an engineering notebook
- Build a robot and program it

Recommendations

- Spend as much time as students need to get comfortable working with the sensors through small activities
- Review how to use an engineering notebook to record designs
- Outline what the path to the “generator” looks like
    - Use tape, blocks, string, etc. to outline a map for the robot to navigate through
    - The map can be the same as the one in lesson 4, or any other design
    - Place obstacles in it that can be bumped by a bump sensor without falling over
    - Obstacles can be in the same places as on the lesson 4 map, or anywhere that seems appropriate
- Remind students about where sensors need to be placed in order to effectively sense the obstacles

Materials/ Equipment

- VEX IQ Robotics Kit
- Computer with VEX Code
- Outline for map (tape, string, blocks, etc.)
- Obstacles for the challenge (blocks, books, etc.)
- Engineering notebook

Vocabulary

- N/A

References

- N/A

ADVANCED			
Level	1	**Lesson**	4
Topic	Testing		
Lesson Title	Testing with Robbie the Robot		
Predicted Duration	2-5 hours		
Lesson Objectives			
● Test the robot ● Complete the challenge ● Record everything in the engineering notebook			
Recommendations			
● Adapt the course to be more or less challenging depending on how students are doing ● Be sure all obstacles cannot be moved by the robot ● Encourage students to use an engineering notebook to record tests ● Encourage students to test multiple times, even if the robot succeeds			
Materials/ Equipment			
● VEX IQ Robotics Kit ● Computer with VEX Code ● Engineering notebook			
Vocabulary			
● N/A			
References			
● N/A			

ADVANCED			
Level	2	**Lesson**	1
Topic	Color Sensors		
Lesson Title	All About Sensors!		
Predicted Duration	1-3 hours		

Lesson Objectives

- Learn about color sensors
- Complete challenges using color sensors in VEX IQ

Recommendations

- Complete the challenge before students try it so most questions can be answered
- Demonstrate how to debug code by sharing an example of a program that is not quite right
- If students complete the challenges quickly, use others provided by the VEX Code VR “Activities” section
- To bridge the gap between coding in VR and in real life, demonstrate use of the color sensor on a robot to the class

Materials/ Equipment

- Projector (recommended)
- VEX IQ Robotics Kit (recommended)
- Computer

Vocabulary

- Color Sensor: detects the color on a surface by measuring the type of light that is reflected off of it
- Debugging: going through code to find and remove “bugs”, or errors

References

- VEX Code VR Information Page
- VEX Code VR Website
- Video about what Debugging is

ADVANCED			
Level	2	**Lesson**	2
Topic	Different types of Object Manipulation		
Lesson Title	What is Object Manipulation?		
Predicted Duration	1-3 hours		

Lesson Objectives

- Understand what object manipulation is
- Learn about the different ways a robot can manipulate objects
- Understand the advantages and disadvantages of different methods of manipulation

Recommendations

- Have students discuss the advantages and disadvantages of each type of mechanism
    - Possibly provide scenarios to think about, such as different shaped objects that they should choose the best type of manipulation for
- Provide examples of each type of manipulation using a robot as a demonstration for the class

Materials/ Equipment

- Projector (recommended)
- VEX IQ Robotics kit (recommended)

Vocabulary

- Plows: apply force to one side of an object, pushing it out of the way
- Scoops: apply force underneath an object to lift and carry it using gravity to keep the object in the basket
- Friction Grabbers: apply force in at least two locations on an object to pinch and carry it
- Lifting Mechanism: a system designed to complete assignments to lift items
- Rotating Joints: a lifting mechanism that utilizes an appendage that rotates around a central point to lift an object
- Linkages: a lifting mechanism made up of smaller components, links, with freely moving joints; when the links move in tandem, the output motion allows for an object to be lifted
- Elevators: a lifting mechanism that uses linear motion to lift objects straight up

References

- N/A

ADVANCED			
Level	2	**Lesson**	3
Topic	Building		
Lesson Title	Building with Design Constraints		
Predicted Duration	1-3 hours		

Lesson Objectives

- Design and build a robot to complete the challenge
- Adhere to the given design constraints

Recommendations

- Set up the field using tape, blocks, etc. that can outline the 1m by 1m square
- Colored blocks from VEX should be used, but can be substituted with any type of object as long as they are all uniform in shape and size
- Have students brainstorm and design in their engineering notebook
- Encourage working in teams of 2-3 students
- Review the sensors and manipulation methods
    - Have students discuss which would be best for this situation
- Adjust the field or design constraints to what fits best for the students and the space

Materials/ Equipment

- VEX IQ Robotics Kit
- Computer with VEX Code Blocks software
- Engineering notebook
- Tape, blocks, etc. for outlining the field
- Objects (preferably blocks from VEX) of same shape and size

Vocabulary

- Design Constraints: specific limitations or requirements that the robot has to meet

References

- N/A

ADVANCED			
Level	2	**Lesson**	4
Topic	Testing the robot		
Lesson Title	Testing		
Predicted Duration	2-4 hours		

Lesson Objectives

- Test the robot
- Record the outcome
- Understand testing process and engineering design process

Recommendations

- Encourage students to test multiple times, even if the first try works
- Encourage students to redesign and improve their robots
- Be sure to guide students with questions if they start to get stuck on how to redesign
- Once students begin making successful robots, try having a competition
    - Who can pick up the most cubes?
    - Who can pick up a certain amount in the fastest amount of time?
- Try having students program a controller and control the robot manually with it
    - This is the next step to having a robotics club/team
- Show some videos of robotics competitions to inspire students to continue learning

Materials/ Equipment

- VEX IQ Robotics Kit
- Computer with VEX Code Blocks Software
- Engineering notebook
- Tape, blocks, etc. for outlining the field
- Objects (preferably blocks from VEX) of same shape and size
- Projector (recommended)

Vocabulary

- N/A

References

- Mini Montage from a VEX IQ Robotics Team